THE

AËRONAUTICAL JOURNAL.

(FOUNDED 1897 in succession to the ANNUAL REPORTS.)

THE ORGAN OF THE ROYAL AËRONAUTICAL SOCIETY.

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Edited for the Council by J. LAURENCE PRITCHARD, Fellow.

All communications should be addressed to the Editor.

No. 135. MARCH, 1922. VOL. XXVI.

Notices of the Royal Aëronautical Society.

Election of Members.

The following members were elected at a meeting of the Council held on February 1st:—

Fellow.—John Case.

Associate Fellows.—Sir Arthur Whitten Brown, K.B.E., M.I.E.E., M.I.Mech.E., L. J. Jones.

Students.—J. Calderwood, H. Gornez-Cornejo, E. A. Skinner, F. B. Ford.

Member.—David Longden.

Associate Members.—G. Hoare, H. L. Reilly, E. E. D. Smith, C. J. Wood.

Annual General Meeting.

Voting members will shortly receive formal notification of the Annual General Meeting, which is to take place in the Library, at 5.0 p.m., on Wednesday, March 29th. The Council's Annual Report and Accounts for the year 1921, which will be presented to members at the meeting, will be found in this issue.

Students' Section.

The next meeting will take place in the Library, at 7.0 p.m., on Thursday, March 23rd, when Mr. S. H. Evans (Hon. Secretary) will open the discussion with "Some Notes on Commercial Aeroplanes," when Mr. A. V. Roe will take the chair. Professor L. Bairstow, C.B.E., F.R.S., Fellow, has kindly consented to give the first annual lecture to the Students' Section in the Library, at 7.0 p.m., on Friday, April 7th, on "Some Aeronautical Problems of the Early Future."

The following paper has been read since the last announcement:—February 23rd, Mr. G. R. Irvine, "Some Possible Improvements in Aero-Engine Installation." Mr. A. E. L. Chorlton, C.B.E., M.Inst.C.E., Associate Fellow, took the chair.

XUM

Associate Fellowship.

The Council have decided to accept the Diploma in Aeronautical Engineering of the Engineering Day College at the Northampton Polytechnic Institute as exempting from the paper in Aerodynamics under the Rules of Examination for Associate Fellowship.

Arrangements for the Month.

March	2, 5.30 p.m.	Lecture by Mr. W. D. Douglas, Associate Fellow, on "Testing Aircraft to Destruction," at the Royal Society of Arts, John Street, Adelphi.
,,	16, 5.30 p.m.	Lecture by Dr. V. E. Pullin on "Radiological Inspection Work."
,,	21, 4.0 p.m.	Library and Publications Committee.
,,	,, 4.30 p.m.	Candidates Committee.
,,	,, 5.0 p.m.	Council.
,,	23, 7.0 p.m.	Students' Discussion Meeting, "Some Notes on Commercial Aeroplanes," by Mr. S. H. Evans (Hon. Secretary). Mr. A. V. Roe in the chair.
,,	28, 5.0 p.m.	**Annual General Meeting** in the Library.
,,	30, 5.30 p.m.	Lecture by Capt. G. de Havilland, on "The Design of a Commercial Aeroplane."

W. Lockwood Marsh, *Secretary.*

57th ANNUAL REPORT OF THE COUNCIL, 1921—1922.

Council.

Chairman: Lieut.-Col. M. O'Gorman, C.B., D.Sc.

Vice-Chairman: Air Cmdre. H. R. M. Brooke-Popham, C.B., C.M.G., D.S.O., A.F.C.

Brig.-Gen. R. K. Bagnall-Wild, C.M.G., C.B.E., Prof. L. Bairstow, C.B.E., F.R.S., Major F. H. Bramwell, Wing Cmdr. T. R. Cave-Browne-Cave, C.B.E., Sir M. D. Chalmers, K.C.B., C.S.I., Sir Robert Hadfield, F.R.S., Capt. G. de Havilland, O.B.E., A.F.C., Prof. B. Melville Jones, A.F.C., Major A. R. Low, Lieut.-Col. J. T. C. Moore-Brabazon, M.C., M.P., Lieut.-Col. A. Ogilvie, C.B.E., A. J. Sutton Pippard, D.Sc., A. V. Roe, O.B.E., Col. The Master of Sempill, A.F.C., Major R. V. Southwell, Lieut.-Col. H. T. Tizard, A.F.C., Brig.-Gen. J. G. Weir, C.M.G., C.B.E., Major H. E. Wimperis, O.B.E., A. E. Turner (*Honorary Treasurer*).

On April 19th, 1921, the Council unanimously elected Major-General Sir R. M. Ruck, K.B.E., C.B., C.M.G., as the first Vice-President of the Society under the new rules, in recognition of his long service as chairman and devotion to the Society's interests. Sir Mackenzie Chalmers, K.C.B., C.S.I., was co-opted to the vacancy thus left in the Council.

The Council are glad to say that the improved financial position which they foreshadowed in their last annual report has been to a considerable extent realised and the Society has been successful in making its income cover its expenditure during the last twelve months. This result has been achieved by the closest economy wherever possible, coupled with the increase in the subscriptions rendered necessary by the serious position which was revealed two years ago. It must, however, be pointed out that the anticipated increased revenue from the new contract for advertisements in the JOURNAL has not been realised, owing partly to the prevailing trade depression and partly to the effects of the old contract, which, though it expired on January 1st, 1921, still leaves certain liabilities.

The report of the Honorary Treasurer in regard to the situation will be found in a later paragraph.

It may confidently be said that the general position of the Society continues to improve owing to a greater part having been taken in the various aeronautical activities. Such movements as the Safety and Economy Committee, the Deputation to the Air Minister on the subject of research, and the institution of more stringent regulations for admission to the technical grades of the Society have undoubtedly enhanced the Society's reputation.

Membership.

The membership numbered 879 on January 1st, 1922, compared with 1,002 at the same date last year; a position which may be considered not unsatisfactory in view of the many calls on individuals at the present time. All subscriptions owing prior to January 1st, 1921, have now been written off and the same course has been followed as to 50 per cent. of those still outstanding for the year 1921. Experience has shown that this view is to a certain extent pessimistic, but it has the advantage of preventing disappointment in the future. The amount of outstanding subscriptions at the end of any single year has in fact fallen very con-

siderably, and improved office organisation has definitely resulted in more prompt payment and the cheaper collection of arrears, so that the number of members is now a criterion of the income.

Representation on Other Bodies.

An invitation has lately been received from the Secretary to the Air Ministry to nominate a representative on the newly formed "Civil Aviation Advisory Board" and Colonel O'Gorman has accordingly been appointed by the Council to serve on that body.

It is desired to tender thanks to the following gentlemen for kindly acting as the Society's representatives on the following committees:—

B.E.S.A. Nomenclature Committee.—Prof. Bairstow, Major Low, Lieut.-Col. O'Gorman, Dr. Sutton Pippard, Major Southwell and the Secretary.

Joint Standing Committee with the S.B.A.C.—Chairman (ex-officio), Vice-Chairman (ex-officio), Prof. Bairstow, Wing Cmdr. Cave-Browne-Cave, Lieut.-Col. A. Ogilvie, Lieut.-Col. M. O'Gorman and Major-Gen. Sir R. M. Ruck.

Conjoint Board of Scientific Societies.—Lieut.-Col. O'Gorman.

Aeronautical Research Committee.—Lieut.-Col. Ogilvie.

British Engineering Standards Association.—Lieut.-Col. O'Gorman.

Advisory Committee on Aeronautical Education.—Lieut.-Col. O'Gorman.

Scottish Branch.

The membership of the Scottish Branch now numbers 67. During the year the Honorary Secretary addressed a number of classes in Glasgow University, including an aggregate of some 900 students.

A very interesting programme of lectures has been held as follows:—

1921.

Sept. 19th.—Mr. Norman Yarrow, "Commercial Aviation in Canada." Lord Weir in the chair.

Oct. 3rd-Oct. 8th.—Sir Ross Smith's Lecture.

Oct. 17th.—Col. V. C. Richmond, O.B.E., "The Organisation of a Colonial Airship Service." Lord Invernairn in the chair.

Oct. 31st.—Prof. Gordon Gray, D.Sc., "Research Work in the Application of Gyroscopes to Aviation." Brig.-Gen. J. G. Weir in the chair.

Nov. 14th.—Major-General Sir Hugh Trenchard, Bart., K.C.B., "Auxiliary Aids to the Royal Air Force." Lord Weir in the chair.

Dec. 12th.—Col. Gold, "The Application of Meteorology to Aviation." Sir John Hunter, K.B.E., in the chair.

1922.

Jan. 23rd.—Brig.-Gen. Bagnall-Wild, C.M.G., C.B.E., "Engine Installation." Sir John Reid, D.L., in the chair.

Feb. 27th.—Mr. A. E. L. Chorlton, C.B.E., M.Inst.C.E., M.I.Mech.E., "Special Light-Weight Engines." Professor Mellanby, D.Sc., in the chair.

Safety and Economy Committee.

In March, 1921, the Council appointed a committee to discuss the question of the type of engine and mechanical arrangements, etc., required for the safe and economical working of an aeroplane carrying mails and passengers between London and Paris. The following gentlemen served on this committee, which held a number of meetings and issued a valuable report which was published by the Society and was most favourably received:—Lieut.-Col. M. O'Gorman (Chairman), Lieut.-Col. L. F. R. Fell, Capt. G. de Havilland, Capt. G. T. R. Hill, Major G. H. Norman, Mr. H. Ricardo, Mr. A. J. Rowledge, Col. F. Searle, Mr. McKinnon Wood, Col. W. A. Bristow, and Wing Commander J. H. A. Landon. This report

was followed by an interesting paper by General Bagnall-Wild on the subject of "Engine Installation" and enhanced official interest in this question.

Associate Fellowship Examinations.

Following upon the adoption at the last general meeting of members of the Council's new regulations for the admission of Fellows and Associate Fellows the Candidates' Committee has drawn up a detailed syllabus for the Society's examinations for Associate Fellowship and a list of qualifying exemptions. These have been adopted by the Council and issued. It is felt that the completion of this work is an important event in the history of the Society as it provides definite technical qualifications by which the standing of applicants for Associate Fellowship can be tested.

Research.

A number of special meetings of the Council have been held recently to consider the best steps to adopt to ensure the continuance of an adequate measure of applied scientific research by the Government and to prevent a continuance of this being submerged under *ad hoc* experimentation—a growing tendency towards which has been evident in the past. These meetings culminated in a deputation being formed, the personnel of which consisted of Col. O'Gorman (Chairman), Prof. L. Bairstow, Sir Mackenzie Chalmers, Prof. Melvill Jones, Lieut.-Col. A. Ogilvie, and the Secretary, who waited on the Secretary of State for Air, on January 17th last, and laid before him a memorandum drawn up by the Council (*vide* AERONAUTICAL JOURNAL, February, 1922, page 43). The result of this interview may be said to have been so far satisfactory that the Secretary showed himself sympathetic. A statement contained in the official paper on "The Progress of Research", and the trend of the resulting discussion, at the Air Conference show that the Council was voicing a general feeling on this point and it is hoped that this action will have good results.

Students' Section.

The Council have felt that efforts should be made to provide better facilities for Student members of the Society to exchange views than is given by their ordinary university or college courses and by attendance at the Society's lectures. A series of monthly Students' Discussion Meetings have therefore been held in the Society's library during the past winter and have met with considerable support, which, owing to the efforts of the Hon. Secretary, appears to be increasing. It was felt that the objects desired would be best achieved by placing the conduct of these meetings entirely in the hands of, and confining the attendance to, students and guests whom they might themselves invite. This has therefore been the case, with the exception that a member of the Society has been invited by the Students to take the chair at each meeting to give any assistance that might be required. Messrs. Stanley H. Evans (Hon. Sec.), Leslie J. Jones and W. H. Rossiter have been elected by the Students as a small committee to make the necessary arrangements, and the following papers have been read:—

Oct. 13th.—T. A. Kirkup on "A Comparison of Different Types of Aerofoils." Mr. H. B. Irving in the chair.

Nov. 10th.—W. L. Le Page on "The Soaring Flight Problem." Mr. F. Handley Page in the chair.

Jan. 26th.—C. Daniel on "Some Practical Points in Fuselage Construction." Mr. J. D. Frier in the chair.

Feb. 23rd.—G. R. Irvine on "Some Possible Improvements in Aero-Engine Installation." Mr. A. E. L. Chorlton in the chair.

In connection with this scheme a fund has been raised sufficient to provide an annual prize to the amount of about £5 for the best paper inaugurating discussion at one of these meetings in any year. This is to be known as "The Percy Pilcher Memorial Prize for Students."

R.38 Memorial Research Fund.

The effects of the Government decision to close down all operations and research work on airships, which had already been the subject of protest by the Council to the Air Ministry, were brought home by the lamentable accident to R.38. The Council decided that the men who were lost in this airship could best be commemorated by something in the nature of endowment of research work in connection with airships in order that there may not be complete cessation of technical development in this country. "The R.38 Memorial Research Fund" was accordingly started and has at present reached the figure of £1,200. The fund remains open and, it is hoped, may in time become considerably augmented. In the meantime Prof. L. Bairstow, Wing Cmdr. T. R. Cave-Browne-Cave, Major R. V. Southwell and Major H. E. Wimperis have been appointed a committee to consider the best method of carrying out the objects of the fund with the money at present available.

Usborne Memorial.

A small sum has been privately subscribed to provide an annual fee for a lecture on an airship subject in memory of the late Wing Commander Neville F. Usborne, who was killed while carrying out an important experiment in 1916.

Lectures.

The Wilbur Wright Memorial Lecture was read on April 12th, 1921, by Mr. G. I. Taylor, who contributed a most interesting paper on "Scientific Methods in Aeronautics."

The programme of the ordinary monthly lectures since the last annual report has been as follows, and the Council desire to thank all the gentlemen concerned for their contributions to the Society's Proceedings:—

1921.

Oct. 6th.—"Some Notes on Aeroplanes in Tropical Countries," Air Cmdre. H. R. M. Brooke-Popham.

Oct 20th.—"The Langley Machine and the Hammondsport Trials," Mr. Griffith Brewer.

Nov. 3rd.—Manœuvres of Getting Off and Landing," Sqdr. Ldr. R. M. Hill.

Nov. 17th.—"Requirements and Difficulties of Air Transport," Colonel F. Searle.

Dec. 1st.—"The Present Technical Position of Airships," Major G. H. Scott.

Dec. 15th.—"Development of the Fighting Aeroplane," Capt. F. M. Green.

1922.

Jan. 5th.—"Specialised Aircraft," Wing Cmdr. W. D. Beatty.

Jan. 12th.—"Boats that Fly" (Juvenile Lecture), Major D. C. M. Hume.

Jan. 19th.—"Aeroplane Installation," Brig.-Gen. R. K. Bagnall-Wild.

Feb. 16th.—"Methods of Instruction in Aeroplane Flying," Sqdr. Ldr. C. F. A. Portal.

Mar. 2nd.—"Testing Aircraft to Destruction," W. D. Douglas.

And the following gentlemen whose lectures will complete the present Session:—

Mar. 16th.—"Radiological Inspection Work," Dr. V. E. Pullin.

Mar. 30th.—"The Design of a Commercial Aeroplane," Capt. G. de Havilland.

Provincial Lectures.

The Council desire to thank the gentlemen who have kindly lectured on behalf of the Society before the following provincial engineering societies:—

Leeds Association of Engineers.—Mr. F. E. Cowlin on "Airworthiness."

Coventry Engineering Society.—Mr. H. L. Stevens on "Full Scale Research on Aeroplanes."

Nottingham Society of Engineers.—Capt. G. T. R. Hill on "The Control of an Aeroplane."

Finance.

The Honorary Treasurer reports:—For the year 1921 the Income and Expenditure Account shows a credit balance of £136 17s. 11d. as against a deficiency for 1920 of £481 3s. 4d. This result is even more favourable than was forecasted in the last report, and now that the Society's current finances are shown to be in a sound position there would appear to be no reason why the special effort then suggested should not be made to increase the reserve fund of the Society by at least £1,500, that being the extent to which the fund had to be depleted to make good the deficiencies of the two preceding years.

It is regretted that the new advertisement contract for the Journal referred to in last year's report, not only failed to realise the increase then anticipated, but has actually resulted in a reduction of the revenue received from this source by over £850. The final result recorded in the preceding paragraph, however, can only be regarded as all the more satisfactory on this account. The accounts have this year been prepared by the Society's own staff; this arrangement being not only more economical, but more satisfactory in every way.

Honorary Officials.

The cordial thanks of the Society are due to Mr. B. Woodward, who has continued to act as Honorary Solicitor, and to Mr. A. E. Turner, whose advice as Honorary Treasurer has helped in no small measure to the attainment of a more satisfactory financial position.

Journal.

The Council would like to express their gratitude to Mr. J. L. Pritchard, the Editor, who devotes much of his own time to the Journal for an honorarium which he is kind enough to remit as a donation towards the Society's funds. The interest and value of the Journal has undoubtedly improved very much since Mr. Pritchard undertook the post of Editor, as is shown by the increase in outside subscriptions and sales, which has been very marked of late.

Staff.

The Society has been fortunate in retaining the services of the Secretary and the office staff, who have worked together with undiminished zeal to further its interests.

AERIAL

BALANCE SHEET,

Dr.	£ s. d.	£ s. d.
To *Nominal Capital*—		
Divided into 20 Shares of 1/- each and 999 Shares of £1 each	1,000 0 0	
,, *Capital issued and called up*—		
17 Shares of 1/- each		0 17 0
,, *Sundry Creditors*		692 8 5
,, *Subscriptions received in advance*		63 11 0
,, *Reserve Fund*—		
Entrance Fees and Life Compositions of present Members as at 31st Dec., 1920	2,562 16 0	
Receipts for 12 months to 31st Dec., 1921	65 2 0	
	2,627 18 0	
Less—Payments	12 12 0	
	2,615 6 0	
Deduct—Income and Expenditure Account Deficiency at 31st Dec., 1920 ... £1,542 19 11		
Less—Surplus of Income over Expenditure for year to 31st Dec., 1921 ... ... 136 17 11		
	1,406 2 0	
		1,209 4 0
		£1,966 0 5

INCOME AND

	£ s. d.
To Office Rental, Light and Insurance	328 4 2
,, Salaries	1,188 13 5
,, Exhibitions and Meetings	84 10 11
,, Printing and Stationery	130 18 4
,, Postages and Messengers	95 2 4
,, Library Expenses	15 16 5
,, Office Expenses	78 15 5
,, Donations	1 13 0
,, Income Tax	20 5 0
,, Audit Fee	10 10 0
,, Journals and Pamphlets	202 16 11
,, Subscriptions written off	82 5 6
,, Balance, being surplus of income over expenditure	136 17 11
	£2,376 9 4

SCIENCE, LTD.

31st DECEMBER, 1921.

		£	s.	d.	£	s.	d.
	Cr.						
By *Office Furniture, etc.*—							
As at 31st Dec., 1920		355	16	8			
Less—Insurance Claim		50	0	0			
					305	16	8
,, *Stock of Journals, etc.*					359	9	9
,, *Stock of Stationery*					26	6	6
,, *Sundry Debtors*, including subscriptions owing ...					256	12	6
,, *Investments at cost*—							
£100 5% War Bond		100	0	0			
£783 6s. 5% War Loan Inscribed Stock, 1921/47 ...		725	13	6			
					825	13	6
,, *Cash in Bank and on deposit*					171	0	1
,, *Cash in hand*					21	1	5
					£1,966	0	5

We report to the Shareholders that we have examined the books of the Society and have obtained all the information and explanations we have required. We are not in a position to judge the value put upon the outstanding subscriptions. Subject to this remark, we are of an opinion that such Balance Sheet is properly drawn up so as to exhibit a true and correct view of the state of the Society's affairs according to the best of your information and the information given to us and as shown by the books of the Society.

(Signed) PRICE, WATERHOUSE & Co.,

18th February, 1922. 3, Frederick's Place, Old Jewry, E.C.2.

EXPENDITURE ACCOUNT.

	£	s.	d.
By Annual Subscriptions	2,331	9	4
,, Interest on War Loan and deposit	45	0	0
	£2,376	9	4

PROCEEDINGS.

SIXTH MEETING, 57th SESSION.

A meeting of the Royal Aeronautical Society was held in the Rooms of the Royal Society of Arts, John Street, Adelphi, London, on Thursday, December 5th, 1921. Major H. E. Wimperis presided.

The CHAIRMAN, opening the proceedings, called upon Wing-Commander W. D. Beatty, C.B.E., A.F.C., to read his paper.

Wing-Commander W. D. BEATTY then read the following paper:—

SPECIALISED AIRCRAFT.

Introduction.

My subject to-night, specialised aircraft, is one capable of a wide variety of interpretations; so wide, in fact, that when I had to tackle the problem I found much difficulty in deciding which of the many possible lines I should take.

However, I realised that the congregation has no say in the sermon, and that your only alternatives were to stay or to walk out. I propose, therefore, to inflict upon those who choose to stay a short account of how aircraft (heavier than air) have been developed in England on specialised lines, followed by some remarks on the special requirements for commercial work, more particularly in respect to those points of design in which the fare-paying user is intimately concerned. In fact the passenger's comfort is really the main subject of this paper.

I would like here to emphasise the fact that I am addressing you to-night entirely in my personal capacity. If, therefore, you dislike my views cast your stones at me and not at the department to which officially I belong.

Military Development.

The development of aviation from its early stage of the hobby of an enthusiastic few to being the pre-occupation of an ever-growing number of serious users has, until recently, been entirely upon military lines.

I will therefore refer briefly to the specialised types of aircraft thus produced to meet military requirements.

The first serious attempt in England to obtain aircraft designed with a definite use in view was made ten years ago, when on 14th December, 1911, conditions were published by the War Office for a competition, to be held the following summer, for aircraft to comply with a military specification. Many of you here to-night may remember all the details of that competition, but for the benefit of those who are not acquainted with them I will give a summary of the specification with which designers endeavoured to comply.

Military Competitions, 1912.

Machines were to be two-seaters capable of carrying a live load of 350lbs. in addition to fuel for 4½ hours.

Top speed was to be not less than 55 m.p.h. with full load. Climb to 1,000 feet was to take not more than five minutes and preferably not more than 3½ minutes. Angle of glide was not to be steeper than 1 in 6. Dual control,

good view for occupants downwards to front and sides and ability to land on and rise from rough ground were also required. Interchangeability of parts, and details in regard to transport by road and rail were also specified, and the engine was to be capable of being started by the pilot alone. In addition to these conditions certain " desirable attributes " were also outlined.

While the main conditions that I have already quoted would be child's play to an aircraft designer nowadays, some of these additional " desirable attributes " are not even yet incorporated in our modern machines, although their desirability has certainly not decreased. These additional points were as follows:—

1. Stand still with engine running without being held. Except in a few special cases this is now ordinary practice.
2. Effective silencer.
3. Self-starter.

   Both these are still conspicuous by their absence on machines now in use. A beginning has, however, been made with self-starters and promising experimental work has been done on silencers.

4. Ease of control:—Considerable strides have been made in this direction, but even so, definite knowledge as to how this can be ensured in the original design appears to be lacking—if we are to judge by the amount of experimental work still frequently found necessary on a new type in order to improve its controllability.
5. Wide range of speed:—Considerable progress has been made in this respect, though further improvement is still anticipated.
6. Good glide with wide range of angles of descent:—Little need be said on this point, though new shapes of aerofoils still occasionally present unexpected difficulties such as reaching the stalling point suddenly on a small reduction in speed.
7. Ease of assembly:—Here considerable improvement is still possible, and I am under the impression that much more attention has been given to this by German designers than by those in England.
8. Stability in flight:—Though much progress has been made, much yet remains to be done and many gaps in our knowledge have yet to be filled by research work and experiment.

At the time these conditions were published they were criticised in many quarters as being too severe. Actually, of 25 competitors, ten were placed by the judges' committee in order of merit, and the first five of these had not been specially designed for the competition. The qualities asked for were, in fact, the attributes of a successful aeroplane and only in a secondary sense military requirements.

In the light of our present knowledge the large majority of the competing machines were highly dangerous, and I doubt if any of our specialist test pilots nowadays would risk getting off the ground in them; indeed, a considerable percentage of the competing machines actually broke in the air later on. Details of the first four machines are given in Table I.

A machine designed at the Royal Aircraft Factory, Farnborough, the famous B.E.2, though naturally not eligible as a competitor, was put through the various tests, and showed itself generally superior to the actual competitors. It was eventually adopted as one of the standard types for the R.F.C.

This was actually the first machine which, arriving from England in a case, was assembled at the Aircraft Park, and flown to the front as a reinforcement early in September, 1914. Within a mile or two of the spot where this photo-

graph (not printed) was taken, Wilbur Wright, six years before, had made his first flight in Europe and proved that the reports of his doings in America were based on fact and not on journalistic imagination.

At the outbreak of war the R.F.C. was equipped with machines intended for general utility work and reconnaissance in particular. Such things as fighting in the air had been thought of, but until experience was gained in the actual use of aircraft in war the lines upon which development was most urgently required could not be determined.

Very rapidly was the required knowledge gained, with war as the instructor, and the design of aircraft for special purposes made big strides. Performance, field of view, offensive armament, manœuvrability, essential equipment, were the main characteristics in the various specifications, the relative importance of each item varying with the purpose for which the machine was required. More, and always more, of each special quality was the cry of the users in the field, pitted as they were against a foe pressing on with similar development, and frequently producing types which for a time surpassed those with which our pilots were equipped.

As on the land, so on the sea the pressure of stern necessity forced on the development of seaplanes designed for various purposes, and of modified land machines for flying off ships.

Thus, by the end of the war the following types were in use. Compare their performances with that specified for the competition in 1912 and you will see the strides made in the six years that followed (Table II.).

This then had been the development on specialised lines produced by war demands from the original "general purposes" specification of 1912. Fifty-five m.p.h. at ground level had become 136 m.p.h. at 15,000ft., climb to 1,000ft. in five minutes had become a climb to 15,000ft. in under 12 minutes, load of crew, fuel, etc., of some 620lbs. had become some 8,490lbs. according to whether speed, climb, or weight carrying was the characteristic specially demanded. Indeed, the speed and climb given above had been attained with a load only some 40lbs. less than that required for the general purpose machine of 1912. Side by side with these improvements in performance had gone improvements in controllability, stability, field of view, strength and general utility. Nor was development limited to the details I have here given, which refer to machines actually in use by the R.A.F. at the close of the war, and which take no account of later types which at that time were in the experimental stage. The figures I have given are, however, an adequate guide to the progress made. The most notable advance, however, was that made in the design and construction of engines.

In 1912 no prize-winner in the military trials used a British engine; at the outbreak of war all our military machines were equipped with French engines. At the end of the war the majority of our machines had engines of British design and construction, though a certain number of French built engines were in use and a number of British built engines of French design, while one American engine was also employed.

Such use of foreign engines was, however, due to the output of engines in England being insufficient to meet the demand—partly as a result of the demands on the factories for other purposes—and not because suitable engines of British design and construction did not exist. Indeed, progress in this respect has been so marked that France has now returned the compliment and arranged for the construction in that country of one of the latest engines of British design—the Napier "Lion."

As regards horse-power, the judges in the 1912 competition remarked of the 120 h.p. Austro-Daimler, fitted in the Cody machine, "This powerful engine seemed to work satisfactorily." The recollection of some of you may also go back to a somewhat heated discussion at Brooklands in the early days, as to

whether it was safe to fit in a monoplane such a high-powered engine as the 50 h.p. Gnome.

Engines of 600 h.p. to 750 h.p. are now actually in use, while the 1,000 h.p. engine is well on its way.

Civil Development.

Having glanced back over the effects produced on the development of aircraft by specialising to meet military requirements, let us now see what has been done as regards aircraft for more peaceful pursuits and the special requirements which commerce demands.

It was not till in the forcing-house of war much fruit of knowledge had been gathered that the science of aeronautics reached a point where it could usefully play a part in the ordinary business of the world. And when peace came, even enthusiasts in aviation knew little of how best to utilise their knowledge. Possible uses and abuses had to be considered in the light of their effect upon the normal life of mankind and safeguards introduced to protect the man in the street from those who desired to live and work in the air above him. The discussion of the terms of peace gave a unique opportunity for obtaining the views of various nations upon these difficult points. On all sides it was realised that aviation eliminated frontiers and that its control was an international matter. General rules of universal application were therefore drawn up and the agreement reached in the International Air Convention recognised, regularised and encouraged commercial communication by air between nations.

In England, the short distances and existing highly developed communications by road and rail offered little chance of obtaining sufficient paying traffic to this new, and as yet commercially untried form of conveyance.

There did, however, appear to be a field worth opening up for pleasure flying, which was at once taken up by various enterprising spirits. Experience soon showed the lines upon which catering for the public taste in this direction could be made to pay, and after three years a certain number of hard-working pilots are still gaining a livelihood from this form of aviation. Low first cost, good flying qualities, and ease of maintenance were the main qualities required in machines for this purpose. Although various ex-war machines have been so employed, the Avro—the standard training machine at the end of the war and now—is that which fills the position in the large majority of cases.

It was to the cross-Channel routes that those desirous of establishing regular air services devoted their serious attention.

A large existing traffic by rail and sea, suffering the inconveniences and discomforts due to the changes from rail to boat and boat to rail and the sea crossing, offered a reasonable prospect that adequate paying loads might be obtained by the air services.

The first organised services were operated with machines of war type, variously modified to meet civil requirements. The demand for aircraft of a special design to meet commercial needs was, however, very early in making itself felt. While aerodynamic requirements are similar in aircraft for both war and peace, other characteristics have entirely different weight placed on them and civil aircraft tend to diverge widely from those military types to which we have hitherto been accustomed. The commercial importance attaching to certain details of design forces on their improvement in a way that the wasteful habits of war failed to do. All such improvement will re-act to the advantage of military designs.

The evolution of new designs, however, requires money, and it is obvious that the pounds obtainable in peace cannot produce improvement as rapidly as the wartime millions.

In commercial design we are, therefore, now at a stage about equivalent to that of military design at that period of the war when slow two-seaters armed with a rifle or a stripped Lewis gun carried on the general air work of the army. The real commercial machine has not yet been developed.

Progress has, however, been made in the right direction and the following are details of some of these early commercial types. (See Table III.)

It may be said that under less difficult conditions than those prevailing on the continental routes, existing types are commercial propositions. Possibly so; the camel may be a commercial means of transport in eastern deserts, but it cannot be considered such for world-wide purposes, and it is for communication throughout the whole world that aircraft have to be developed if they are to fulfil their obvious destiny.

Let us now study in more detail the special lines upon which aircraft should be developed if their commercial use is to be established on a sound basis. In the first place constructors will be forced to realise that their job is to meet the user's wishes to the best of their ability, and not to provide him with their own idea as something "just as good."

Possibly designers will say that they were harried to death during the war in their endeavours to meet the conflicting desires of various users. There may be something in that contention, but I think it is an undeniable fact that the user's wishes were never fully complied with in detail on any machine that went to the front. Though partly due to war pressure and the necessity of avoiding delay in output, this was mainly due to the fact that the user in war was under orders and had to use what he was given. The fear of "delay in output" was always urged and frequently accepted as a reason why "just as good" should be made to do.

In commerce the same will not apply. If the user is not satisfied—and by user in this case I mean both the operating firm and its paying traffic—then the transport firm will lose its traffic and the constructor will get no more orders.

Commercial Requirements.

Now one way of arriving at the user's view of his machines is to study them from the point of view of the profit and loss account of the operating firm.

Take the expenditure first. This it is obviously desirable to reduce; therefore we require the following qualities in our specialised commercial machine:—

Low first cost.
Economical to maintain.
Economical to run.

By careful design manufacture can be simplified and expensive fittings eliminated. Strength is also required, not only from the point of view of safety, but also in the form of resistance to wear and tear. Moving parts, and friction between them should be reduced to a minimum. Parts which require attention must be easily accessible. The engine in particular must be readily removable either complete by itself or complete with its mounting. This is a point on which I should like to see comparative tests carried out by operating firms. Is it more economical to change the engine by itself or the whole engine and mounting complete? The latter might be the quicker operation, and therefore cheaper in labour costs, but it will have to bear the charges due to the additional capital outlay on spare mountings.

The engine, again, should be capable of running long periods without overhaul. I believe that at present we are getting close to a standard period of 100 hours between overhauls, but we want 300 to 500 hours as a normal working period. Economy in running implies low power, and to get a high useful load for less power improved aerodynamic efficiency is required.

Let us now turn to the receipts side of the account. Naturally it is desired to increase these figures. First, therefore, we must have a large load-carrying capacity. But this capacity is of no avail if the traffic to fill it cannot be attracted. Jonah's whale may have been, and probably was, capable of carrying twenty people quicker than an express train, but can you imagine any useful traffic being attracted to such an uncomfortable and malodorous conveyance?

Passengers' Needs.

You have recently heard in this hall the views of an operating firm as to their detailed requirements in aircraft for commercial purposes. I propose, therefore, largely to neglect that important aspect of the matter and mainly to discuss the special need of the other branch of the users of aircraft, that is the passengers.

Far more attention is necessary to the comfort of passengers, and this embraces a wide variety of detail. I cannot but think that considerable advance might be made in forthcoming commercial types were designers to travel to and from Paris in each of the various types of aircraft actually in use on the cross-Channel services. This is the slack time of the year for passenger traffic; why should not the transport companies grant a certain number of free return tickets to *bona-fide* designers, thus affording them opportunities to ascertain in their own vile bodies the various existing causes of discomfort and learn what to avoid. Passengers are the most important source of revenue for air transport firms at the present time, and each that considers that he has had a really comfortable journey is a walking advertisement for the air line, while each dissatisfied passenger will result in a lowering of possible receipts.

Silence.

First and foremost amongst the important items affecting comfort I would place silence. A "desirable attribute" in 1912, it has never yet been attained in normal practice and the air line passenger still suffers acute discomfort from the noise to which he is subjected.

It is true that the noise in a machine comes from a variety of sources, but it is urgent that some at least should be eliminated. Promising exhaust silencers have appeared experimentally; it is for designers to incorporate them in their designs. Never should an open exhaust point in the direction of the cabin. Get rid of the barking roar of the exhaust and it becomes possible to identify and so to eliminate the other noises. Probably modifications in the design of propellers may be desirable, and with a silent exhaust it becomes an easier matter to compare the noise effect of two different propellers. Fabric covered fuselages must also, I think, be relegated to the past; a stiff wooden covering does not transmit to the interior of the cabin the blows from the slipstream in the same way that fabric does. Vibration and resonance are closely allied to noise in their effect on passengers and should be eliminated. It may be necessary on these grounds to ensure that the two engines of a twin-engined machine never synchronise. I believe Colonel Bristow is trying experiments on these lines. Engine designers will need to utilise motor car experience and get rid of that variety of noises from gears and other moving parts which at present are so obvious in an aero engine when its exhaust does happen to be silenced.

Ventilation and Heating.

The next important detail which designers should carefully study is that of ventilation, to which very little attention has hitherto been given.

Adequate ventilation of the cabins of commercial aircraft is a problem that presents considerable difficulty. The cubic space available is very limited, so that the air inside the cabin tends to become vitiated rapidly, while the speed of

the machine is such that the velocity of in-coming air is often so high that the passenger feels a draught. In rough weather, therefore, the unfortunate passenger tends to suffer from depression, headache, cold and illness.

The monk of old may in time have found his hair shirt to be a comfortable garment, but it is at least probable that at the first time of wearing he desired to remove it; and passengers who are not compelled to do so will not repeat an uncomfortable journey by air.

For many years the efficiency of ventilation has been determined by the quantity of carbon dioxide present in the atmosphere. The supply of air generally recognised as necessary to remove all sensible impurities amounts to 3,000 cubic feet per hour per person. In a present day cabin of 300 cubic feet—seating ten passengers—the air must be changed 100 times an hour if the standard allowance is to be provided. In practice, such a rate of change is unobtainable, except in unbearably draughty conditions.

It is clear then that the measurement of the CO_2 content is likely to continue to give unsatisfactory results in aircraft.

Professor Leonard Hill, however, has pointed out that the 3,000 cubic feet figure can be much reduced if the cooling, drying and radiant energy conditions are satisfactory. To afford a means of determining these conditions he invented the "Kata" thermometer. Experiments have shown that the information given by this instrument is an accurate guide to the adequacy of the ventilation so tested, and if the results obtained from its use average between six and eight the conditions may be considered satisfactory.

Now the cooling and drying effects of air depend largely upon its rate of movement, and it may be taken that if the temperature of the air is 55° to 60°, its velocity at the inlet to the cabin should not exceed $4\frac{1}{2}$ feet per second, if the inlet is 18 inches or more from the passenger, or 3 feet per second if it is less than 18 inches from the passenger.

With inadequate warming arrangements, a change of air more frequently than three to five times an hour is likely to be uncomfortable in the normal cabin, and under such conditions it may be found necessary to keep the velocity of in-coming air down to $1\frac{1}{2}$ to 2 feet per second.

The velocity of out-going air may be as much as 10 feet per second at the orifice, particularly if that is at least 18 inches from the passenger.

Designers should, I think, aim at providing for some twenty changes per hour, taking care to avoid draughts and make satisfactory heating arrangements.

If it is found that the air is being changed too rapidly for comfort, it is a very simple matter to close up some of the openings. It is far more difficult for the user of the aircraft so to alter it as to increase the regular supply of air if the original arrangements have proved inadequate.

Now how is the air to be changed? Experiments in America on sleeping cars showed that, provided the foul air was expelled, an ample supply of fresh air found its way through cracks and crevices in a swiftly moving vehicle.

Personally, I think it better to arrange for the removal of the foul air than to trust to luck to its finding its way out. It should be practicable to design suitable aspirators to draw the air from the cabin of an aeroplane—slightly above the floor level, for, though hot air rises, vitiated air tends to descend. It is probable that air entering through cracks and crevices will do so at such a velocity as to be a source of discomfort to passengers, particularly as its temperature is likely to be low. Air inlets should, therefore, be arranged at the front of the cabin, somewhat below the roof; the velocity of air entering here can readily be governed by the insertion of right angle bends in the trunks leading to the inlets; each such right angle bend reducing the total flow by 50 per cent.

TABLE I.

TABLE I.

SUCCESSFUL MACHINES AT THE MILITARY COMPETITION 1912.

TABLE I.

SUCCESSFUL MACHINES AT THE MILITARY COMPETITION 1912.

Order of Merit.	Type.	Engine.	Speed at Ground Level (m.p.h.)		Climb to 1,000ft. (Mins.)	Weight (lbs.)		Weight (lbs.) per	
			High.	Low.		Gross.	Load.*	sq. ft.	H.P.
–	Specification		55 (min.)	—	5 (max.)	—	—	—	—
1	Cody ...	120 h.p. Austro-Daimler	72.4	48.5	3.5	2658	710	5.55	23.8
2	Deperdussin	100 h.p. Gnome	69.1	59.0	3.0	1854	670	6.1	23.4
3	Hanriot ...	100 h.p. Gnome	75.2	59.9	2.7	1866	701	6.4	24.0
	M. Farman	70 h.p. Renault ...	55.2	37.4	4.0	1919	601	2.9	26.8
–	B.E.2 ...	70 h.p. Renault ...	70.0	40.0	2.76	1700	620	4.55	23.5

* Load as here given includes fuel, crew and military load.

TABLE II.

DEVELOPMENT OF SPECIALISED MILITARY AIRCRAFT IN SIX YEARS FROM 1912.

TYPE.	ENGINE.	SPEED.		CLIMB (mins.)		WEIGHT.*		LOADING.	
		m.p.h. at				Gross.	Load.	sq. ft.	H.P.
Military Competitions, 1912.	Specification.	10,000	15,000	10,000	15,000	Say	Say	Say	Say
		55 at ground level		1,000 in 5 mins.		1,800.	650.	6 0	24.0
Training.									
Avro 504K.	110 Le Rhone ..	80	—	23.6	—	1853	558	5.65	14.5
Fighters.									
Martinsyde F.4	300 H.S.	142.5	136.5	6.7	11.8	2289	579	6.95	7.5

Military Competitions, 1912.	Specification.	55 at ground level		1,000 in 5 mins.		Say 1,800.	Say 650.	Say 60	Say 24.0
Training.									
Avro 504K.	110 Le Rhone ..	80	—	23.6	—	1853	558	5.65	14.5
Fighters.									
Martinsyde F.4	300 H.S.	142.5	136.5	6.7	11.8	2289	579	6.95	7.5
S.E.5	200 Viper H.S. ...	—	120.	10.8	20.8	1988	520	8.00	9.8
Sopwith Snipe	200 B.R.2	118.	112.5	8.8	17.8	1950	710	7.2	8.55
Bristol Fighter	275 Rolls	113.	105.	11.8	23.8	2848	845	7.00	10.4
Reconnaissance and Day Bombing.									
D.H.4	360 Rolls	130.	124.	11.3	20.9	3576	1067	8.2	9.9
D.H.9	240 Siddeley Puma	110.	101.	18.9	38.8	3316	1115	7.6	13.8
D.H.9a	400 Liberty ..	120.	114.	11.8	22.8	4220	1450	8.55	10.65
Night Bombing.		6500		6500					
H.P. 0/400	2/360 Rolls ...	84.5		27.2		13360	4858	8.1	18.6
Vickers Vimy	2/360 Rolls ...	95.		33.		12500	5399	9.4	17.4
H.P. V/1500	4/360 Rolls ...	97. (8750)		18.5		24700	8490	8.55	17.2
Ship Aeroplanes.									
Sopwith Camel	150 B.R.1	119.	113.	11.5	25.	1530	494	6.7	10.2
Parnall Panther	230 B.R.2	103.	—	17.1	—	2595	1267	8.0	11.4
Torpedo Aeroplanes.		Knots at 6500		6500					
Sopwith Torpedo	200 Arab	89.		15.7		3883	1684	6.85	18.75
Blackburn Blackbird	360 Rolls	78.5		16.2		5700	2472	8.35	16.5
Seaplanes.									
Hamble Baby	110 Clerget	78.		25.		1946	76	5.6	

Blackburn Blackbird	360 Rolls	78.5	16.2	5700	2472	8.35	16.5
Seaplanes.									
Hamble Baby	110 Clerget .	78.	25.	1946	560	7.6	17.1
Short 184	260 Sunbeam ..	73.	33.8	5363	1660	7.9	20.8
Fairey 3C.	360 Rolls	96. (2000)	9.5	4800	1408	10.08	13.5
Flying Boats.									
F.2 A.	2/360 Rolls .	80.	16.5	11084	3362	9.75	16.1
F.5	2/360 Rolls .	86.	16.1	12268	4245	8.7	17.8

* Load as here given includes fuel, crew and military load.

TABLE III.

EARLY TYPES OF COMMERCIAL AIRCRAFT.

Type.	Engine	Speed (m.p.h.).				Climb.			Weight (lbs.)		Weight per	
		Ground Level.		3,000 ft.	6,000 ft.	Height (ft.) above ground 275 yards from start.	3,000ft. (mins.)	6,000ft. (mins.)	Gross.	Load.*	sq. ft.	H.P.
		High.	Low.									
Avro (1912) ...	60 h.p. Green	61.8	49.3	—	—	—	9.5 to 1,000ft.		1,762	571	5.28	27.2
Handley Page W/8	2/450 h.p. Napier Lion	119	55	—	—	74	—	—	11,443	3,593	7.86	11.55
		—	—	—	—	—	—	—	12,500	4,750	8.58	12.40
Vickers Vimy Commercial ...	2/360 h.p. Rolls Royce	103	50	—	—	26	—	—	11,057	3,267	8.28	15.71
		—	—	—	87	—	—	39.5	12,500	4,925	9.37	17.8
De H. 18 ...	450 h.p. Napier Lion ... (5 to 1 compression)	—	—	120.2	117.2	—	5.0	12.3	7,000	2,690	11.21	16.05

* Load as here given includes fuel, crew and useful load.

It must be remembered that it is essential that the in-coming air should be free from impurities, due to exhaust gases, petrol fumes, stale oil, and so on.

Special arrangements for the aspiration of the air from the engine compartment—which should in any case be bulkheaded off from the passenger cabin—may be of value in preventing leaks of impure air into the cabin.

Heating is closely bound up with ventilation, and at the temperature likely to be met with in ordinary flying it is essential that arrangements should be made for warming the cabin. It is possible to arrange for a supply of air heated by the exhaust pipes, but it should be remembered that air that has been in contact with metal heated to some 200° C. is definitely unsuitable for breathing. Those of you who may have tried to handle a loose exhaust pipe in the air, even with thick gloves, will realise that 200° C. is a low estimate of its temperature. If a muff on the exhaust is used, it should therefore be stepped up, the in-coming air for the cabin being taken from the outer step.

Some of you, however, may remember the footwarmers which Cody fitted to his machine, heated from a bye-pass off the engine cooling system. While there are objections to the introduction of such complications in a matter so important as the running of the engine, no serious difficulty should be experienced in fitting a hot water or steam heating system which draws its heat from the exhaust. Such a system, once developed experimentally, should prove very satisfactory and require little or no attention, while its weight ought not to be excessive.

A suitable arrangement for ventilation and heating might be as follows:—At the forward end of the cabin fresh air enters at a rate of 3 feet per second through an inlet about 12in. by 12in. in size, slightly below the roof. Aspirators arranged below the seat level at the back of the cabin suck out the vitiated air. An exhaust heated tubular boiler supplies steam or hot water to a radiator fitted two or three inches in front of the fresh air inlet and the same heating system includes footwarmers in the cabin floor. Such an arrangement should imply fresh air, warmth and comfort for the passengers.

The form of construction of the cabin directly affects its warmth, and from this point of view the fabric-covered cabin is very bad. With this material radiation to the outer air is so rapid that adequate warming in cold weather is almost out of the question.

While comfort, warmth and adequate ventilation will remove some of the causes which predispose to air sickness, other psychological causes will still remain. Here the designer has little say in the matter, but in parenthesis, I may suggest that some thought should be given to occupying passengers' attention. The development of a loud speaking attachment for the wireless telephone might be of advantage; fitted in the cabin it would enable the passengers to hear the remarks passing through the ether, though it might then be found necessary to tone down some of the personal conversation that nowadays takes place between individual pilots. Or the firm's representative who travels in some machines might inaugurate a game of " put and take "—thus making the roughest journey against a head wind pass with rapidity and amusement. Of course, some individuals might consider such preventive measures worse than the disease.

I am indebted to Colonel Heald, the medical adviser to our department, for much of the information upon which the foregoing is based.

Seats.

However, I must return to the subject of passengers' comfort, and I wish to say a word or two about seating accommodation. It always seems to me that chair designers work entirely by tradition, and that if any scientific study of the subject has been made, no attention has been given to the conclusions reached.

If the tyres on the wheels of a motor car are too small, the vehicle is uncomfortable to ride in and the tyres wear out rapidly. Similarly, if the weight of one's body is carried by a small portion of it, that part quickly gets fatigued and the whole body feels uncomfortable.

Only too often seats are designed so that an unnecessarily small portion of one's anatomy bears the majority of the weight. Why should not designers study the problem carefully in conjunction with anatomists and produce a light chair properly designed to suit the human form and to keep the loading per square inch of flesh at a low figure?

Nature of Route.

Many details of design will be affected by the nature of the country over which machines are operating. Aeroplanes, flying boats and amphibians will each have their special fields.

I do not propose to weary you with detail on this point, but I have here some slides showing what has been done experimentally to meet special conditions in snow-covered country. For the photographs (not printed) from which these slides were made I am indebted to Captain F. S. Cotton in regard to those from Newfoundland and to Major C. H. R. Johnstone for that of the Sopwith, which was taken in Sweden.

Number of Engines.

There is room for much diversity of opinion in regard to single engine versus twin engine, or multi-engine machines. While traffic is small the lower first cost and running cost of a single engine machine has an important bearing on the matter. If a twin engine machine will carry nearly double the load of a single engine machine, it immediately becomes a serious competitor economically if the available traffic is sufficient to fill it. Here arises the problem of how large can a fuselage be built practically for a single engine machine. In military aircraft great weight can be carried in a small compass as the load is in a very condensed form. But in commercial types there will be a continual demand for more cubic space per passenger. Will fuselages be necessarily so large that high-powered engines will be economically unsound? In the De H.18, eight passengers are carried at 56 h.p. each; in the De H.32, eight at 45 h.p. each.

Let us assume that we are considering the use in a single engine passenger aircraft of a 1,000 h.p. engine. For that power we must accommodate at least 22 passengers, and we should endeavour to allow at least 40 cubic feet of space per head. Is such a fuselage practicable for a single engined machine? What is the limiting size? How is propeller efficiency likely to be affected? These questions, which also concern the practicable size of twin engine aircraft, are matters on which I feel sure that engine designers would like the considered views of aircraft designers, otherwise they may be devoting their attention to engines of a size likely to be unsuitable for commercial work.

The twin engined machine has some advantages over the single engined, particularly if it will fly on one engine. Greater reliability is thereby secured, and to the psychological desire of many passengers for a machine with more than one engine is added the greater favour with which insurance companies may regard it.

Salvage.

From the insurance point of view, emergency exits for passengers should be provided and the question of salvage is of some importance. Attention to details which facilitate quick repairs in the event of trouble, and easy transport of spare parts, may assist a constructor in obtaining the favour of those august under-

writers, whose opinions are reflected with much emphasis in the balance sheet of the transport firm.

There are, of course, methods of salvage which have been developed entirely independently of the design of the machine, though I doubt whether insurance companies would look with favour upon practices based on the occurrences illustrated in the following slides.

Conclusion.

The development of specialised aircraft on military lines will tend to progress more slowly as less and less money is devoted to military purposes by the various nations. It is by proving its value to the commerce and communications of the world that aviation will really enter upon a period of rapid useful development. If any of my remarks this evening help at all towards the production of the real commercial machine, which will supply to the financiers of the world convincing proofs of the commercial possibilities of air transport, I shall feel amply rewarded.

DISCUSSION.

The CHAIRMAN, after the reading of the paper, said that Wing-Commander Beatty could not have treated the subject in a more illuminating way. To compress so large a subject into such a small compass was a very remarkable achievement.

Sir SAMUEL INSTONE, at the invitation of the Chairman, opened the discussion. He represented, he said, purely the commercial side of aviation. He was not a technical man, and never had posed as such, but they would agree that commercialism was essential to the air industry, and one could not succeed, perhaps, without the help of the other. Looking at the subject with the cold commercial eye might not appeal, perhaps, to those who had devoted their intelligence to the development of aircraft. He begged them, however, to look upon commercialism as a friend and not as an opposing force to the progress of aviation. He had listened with the greatest possible interest to what he might candidly call a remarkable paper, given in a remarkable way by Wing-Commander Beatty. It was particularly encouraging to one like himself, who awaited the arrival of a real commercial aeroplane, but the real commercial aeroplane, to his mind, could not arrive until those engaged in the designing and building of aeroplanes received proper encouragement from the proper quarter. There was no hiding the fact that the progress of aviation depended more and more on money, and the financiers of the city, and elsewhere, and those who had money at their disposal, together with the imagination—for one was very essential to the other—had not the means at the present time to put what they ought to put into this side of aviation, which undoubtedly had an enormous future, and on which, he would go as far as to say, the future of the country would depend. Commerce had been bled white by taxation—he said that with all seriousness, and those who should have, and would have had, ample means for the development of civil aviation, in the same way as the merchants of the City of London developed the Mercantile Marine in days gone by, had not the means at their disposal, having had to make provision for taxation, that the industry had a right to expect. The result was that they must look for encouragement from the proper quarter, and that was the Government. They would say that what the Government spent would re-act upon the taxpayer, and that if they asked for more money they would have to find it on the turn of the wheel. He put it to them that where £16,000,000 was allocated by the Government for aviation, it was incomprehensible that out of that sum a paltry £200,000 was apportioned to civil aviation. When they considered that little countries like Czecho-

Slovakia, and even smaller countries, were putting aside perhaps double what the great British Government was allocating to civil aviation, was it reasonable to expect our designers and builders to keep together their technical staffs and to devote their time and energy to the creation of machines which were to compete in the progress of the world on a paltry £200,000 per annum? That was not all—and here he hoped the author would remember his own words, that he was speaking that evening entirely in his personal capacity, and not for the Government or his Department, and would not take as a personal matter anything he (the speaker) was going to say. Not only was there only £200,000 allocated for commercial aviation, but it seemed to him, in the various interviews he had had with officials, that their ambition in life seemed to be, not how best that £200,000 could be spent, but to see how much they could save out of it. He knew the civil servant had not the freedom of the man in commerce trading on his own account, and he dare say that it was a feather in the cap of anybody who could go to his chief and say that he had saved £190,000 out of that £200,000 (laughter). What was the consequence? It must be that progress was restricted. He would go further and say that where subsidies were granted, it was only natural that there were restrictions, and those in charge being technical men, every one had his little pet theory, and liked to put it into operation and see it tried, and perhaps imposed it upon those with commercial experience; that was hampering. As against that £200,000, the allocation by the French Government meant that the French civil aviation companies had £3,000,000 sterling to play with. Wing-Commander Beatty had thought of all the things that were necessary to make civil aviation the most comfortable, the cleanest and the most pleasant means of travel, but unfortunately they must have assistance. If those present would cast their memories back, at the first Air Conference that was called at the Guildhall he had the pluck to stand up amongst all the experts, and was the only one to speak the truth in that way (laughter) and say that civil aviation was not a commercial proposition. He had said that civil aviation could not pay. He was surrounded by some eminent gentlemen, and one had said that they did not want subsidies and would run a service without. They did; for five minutes, he believed. He had told them that the only remedy must be for the Government to purchase the machines and rent them out on hire to those companies who could run them. What had happened had been precisely what he had predicted; the Government had bought machines and were lending them out to the operating firms. But still, he said again that it was not a commercial proposition, and he would say to anybody, especially any Government servant who thought that there was going to be any profit made out of running those machines, that it was a fallacy. Until things returned more to their normal condition in the City it was only to the Government that those interested in the progress of civil aviation could look. There were one or two points he would like to mention in connection with the remarks of Wing-Commander Beatty. He had said that a certain number of free return tickets should be granted to *bona-fide* designers by the operating companies. On behalf of his own company he would say that they had always done that on demand, but strange as it might appear, they had had very little demand for such facilities. Whenever a demand of that nature had been made, his company had been only too pleased to give a free passage or to grant any facility asked for, and he could make that a promise for the future.

There was one remark he would just like to make *en passant*, and that was that he was rather surprised, and pleased, to see that Wing-Commander Beatty had come to the conclusion that there were certain advantages in twin-engine machines. In discussing the programme for operating their new service, his brother and himself had tried to impress with all possible force that some regard must be paid to the public, if it were the public they were catering for, and he had no hesitation in saying that the public would always travel in a twin-engine machine when it was possible. There was an element of safety, the machine

looked safe, and the public thought they had two chances at least of coming back safely; if one engine failed there was another to carry on, and if the operating companies were going to look after the demands of the public, they should have more support than they were receiving at present. He believed he was right in saying that twin-engine machines were definitely refused to them and single-engine machines imposed upon them; of course, that only applied to the machines which the Ministry were renting to them. Thank goodness his firm had a few pence left to indulge in the development of machines for themselves; but more attention must be paid to the demands of the public, and theories must not be imposed upon those who, by practical experience, had felt the public pulse and knew what the public wanted.

Mr. F. HANDLEY PAGE said that the question of specialised machines for commercial work, in which he was particularly interested, was one that merited a great deal of attention. If one referred back to the early days when motor-cars were first introduced, they were, after all, only horse-drawn vehicles with the horse taken out and the motor put in, and eventually they became specialised transport having a definite characteristic of their own. So, too, he believed they would find in time that commercial aircraft would become very definitely specialised, quite distinct from the early box-kite, string, wires, fabric and so forth, and become vehicles which would have very little head resistance, wires reduced to a minimum, landing carriage pulled up inside possibly, and the body and every detail studied so that no horse-power was thrown away. Then he thought it would be possible to get real reliability in aircraft. No longer would they need an enormous engine running full out all the time, but, once the machine had climbed to the desired height, the engine would be throttled down and run at a half or a quarter its horse-power, and therefore have a longer life. In the ordinary motor-car the horse-power, during the greater portion of the time the engine was running, was a comparatively small portion of that which it could develop as a maximum.

Inside the aircraft, too, greater attention would be paid to the comfort of the passengers. As Wing-Commander Beatty had pointed out, that was one of the major things to be studied. After all, if a passenger paid his fare, he was the individual who, in sufficient quantities, they hoped would make the lines pay, and therefore the question of providing him with sufficient air to breathe, and so forth, was a most important point.

He would like also to extend the invitation to designers to travel on his company's machines. Perhaps his firm might not always have so much room as Sir Samuel Instone (laughter), so that he hoped that on the day when designers applied, the machines would not be overcrowded with passengers (renewed laughter). Some of the gentlemen present had already travelled on his machines.

It was most interesting to him that evening to find the subject of twin-engine machines referred to again, particularly in reference to those who had travelled. He had had an opportunity that afternoon of speaking to a very distinguished member of the Royal Aero Club, whom he was pleased to see present. That gentleman had said that he (Mr. Handley Page) was responsible for the most abominable creation in aviation, namely, the twin-engine machine. That was a thing that he (Mr. Handley Page) knew perfectly well was no good, and never would be any good, said the gentleman referred to, and the sooner all twin-engine machines were off the service so much the better for civil aviation. He (Mr. Handley Page) thought that gentleman must have been speaking as the result of a rather unfortunate occurrence as he had been a passenger, but after all that abuse he had admitted that he would be quite willing to travel again in a similar way if he (Mr. Handley Page) would offer him another seat (laughter).

There were a great many technical details in Wing-Commander Beatty's paper to which one could refer at great length had time permitted. It was of

particular interest to all aircraft designers to see the details which medical evidence had shown to be so necessary for comfort, namely, the heating of the cabins, change of air, and things of that nature. It was to the perfection of those details in a specialised way that success would eventually come in the production of a real commercial aircraft.

Major C. C. TURNER took exception to the lecturer's remark that Great Britain was a country so small that we were handicapped with regard to the length of air routes. The remark had nothing at all to do with the subject of the lecture, but there was a very common impression that Great Britain was too small to run sufficiently long commercial air routes. He merely wanted to say that the distance from London to Glasgow was something like 400 miles, and that there were various routes within the United Kingdom which should, he believed, give scope for commercial air lines. One of the speakers in the discussion had made a very downright and explicit statement that commercial aviation at the moment was not a paying proposition. That was probably the experience up to date, but he himself wanted to put it that commercial aviation had not yet been given a chance. They were running commercial aviation in this country on the basis of one very limited route with a mileage of about 85 or 90 miles —London to Lympne, London to Paris, London to Brussels, and occasionally, he believed, London to Amsterdam. The only subsidised routes were those from London to the Continent. It seemed to him that they were limiting British aviation in a most unfair way, and they could not expect to run a business on the smallest possible basis and make a profit out of it. The only way to run a business was to enlarge the basis as much as possible, get the greatest possible turnover, reduce the proportional overhead charges, and so make a profit. What they were doing now was trying to make civil aviation pay with ten machines running, divided between three or four companies. It was absolutely impossible. He regretted to say that he had failed to discover much in the course of the lecture to justify its title—"Specialised Aircraft." It seemed to him that the discussion had drifted to a general discussion of commercial aviation without much reference to technical matters, but the question of two-engine machines as against single-engine machines had arisen. On that question there was no doubt at all that the public, for some reason or other, preferred to fly in two-engine machines, and whenever they had an opportunity of choosing, they preferred to go in a two-engine H.P. or Vickers rather than a single-engine D.H., or whatever it might be. That preference seemed to him to be based upon a lack of information. A two-engine machine, properly designed, was undoubtedly to be preferred to a poorly-designed single-engine machine, but there were a great number of two-engine machines in operation to-day which did not provide a reasonable margin of safety for the passenger. The subject was capable of discussion from the technical point of view, to differentiate between perfectly sound two-engine types and unsound two-engine types, and he rather regretted that the discussion had drifted away to general air transport problems, instead of being directed towards the technical aspect, which, from the title of the lecture, he thought they were entitled to expect.

Major D. H. KENNEDY said it was of some significance, in view of the fact that Wing-Commander Beatty had devoted so much attention to commercial aviation, that nothing whatever was said about the development of specialised aircraft for the carriage of letters and parcels. That seemed to him significant as showing that our rulers were absolutely devoid of imagination at the present time, and were quite content to leave commercial aviation to struggle along under the most tremendous handicap. If they considered that we had already a very considerable air traffic between two capitals—Paris and London, and that there were people who found it convenient to send parcels of various kinds, then was it too much to suppose that there was a desire to send the same sort of goods quickly between the capital of England and the capital of Scotland? It would

be said that parcels could be sent by rail. When there was no rail they were sent by coach, and before that they were sent by carrier; but in every one of those cases, when they looked back, they would see that somebody had to have faith and imagination, and had first of all to provide the facilities. There was no traffic on a road until a road was provided. If they accepted that as good reasoning, the question was who was to have the faith. They could not expect that faith to come from a commercial company, and they should not expect a commercial company to do it; and therefore they got back to the inevitable fact that it remained for the Government to have imagination and faith to say that we were to have commercial aviation. We must first of all provide the funds and the facilities, then the traffic would inevitably come.

Sir SAMUEL INSTONE interposed that, as regards specialised aircraft, the point raised by Major Kennedy was a very important one, and it might interest Major Kennedy and others to know that his own firm were having constructed three special aeroplanes for the purpose of carrying goods, and goods alone, in order to develop the particular business mentioned by Mr. Kennedy. They had come to the conclusion that passengers did not like to, and ought not to, travel in a luggage van, which present aeroplanes were almost being converted into, and it would perhaps satisfy Major Kennedy to know that something in that direction was being done.

The CHAIRMAN pointed out that little had been said in the discussion about the general question of research. The relation of research to civil aviation was naturally the aspect which struck him most. Mr. Handley Page had compared the aero engine with the motor-car engine, pointing out that the motor-car engine worked most of its time at mere fractions (say, 30 per cent.) of its rated output, whereas the aircraft engine had, especially during the war, been pushed up to 100 per cent., or but little less, and was only now getting nearer the motor-car performance in that respect. The Napier Company had told him that their Lion engine, when on civil aviation service, ran during a normal passage on but 60 per cent. of its rated power. That was a real step towards what, in the motor-car industry, had been shown to be the best way of making an internal combustion engine efficient and reliable, *i.e.*, an internal combustion engine as they now knew it. Were they going to know it in its present form for long? The efforts of research workers were directed towards its improvement in pretty well every conceivable way. For instance, they were dealing with such a purely engineering proposition as conversion to air cooling, a change extraordinarily important for machines which were going to operate over desert countries. That was an instance, from the purely engineering point of view, of what research work was aiming at. At the other end of the scale they had research work on purely scientific lines, such as that on the production of materials of much greater strength in relation to their weight. For instance, it had been shown that steel had a tensile strength of only about one-tenth or so of what it should be in an "ideal" condition. Between two such forms of research as these, the purely engineering and the purely scientific, there was a great body of work to be done which would have a tremendous effect on all aviation; it would have a very big effect on the engineering industry itself, but most important of all, on military and civil aviation. From the civil aviation point of view, however, "silence" was a most important requirement; it was first and foremost. This meant silence in two things—in the exhaust and in the propeller. Silence in the exhaust had been attempted on numerous occasions, and he was glad to be able to say that the simplest form of all of silencing the exhaust was as efficient as any other method that had been tried, however complex. Silencing the propeller was equally important, but the aerodynamic work that was involved was exceedingly difficult, and it was not certain that success could be achieved; it was essential, however, to keep on trying. If that work could succeed, then civil aviation would be enormously advanced in the public esteem. The question

of single versus two-engine machines was too long a story to start at that hour, but he mentioned that schemes for water-cooled engines with horse-power as high as 2,500 were under consideration. He emphasised his very strong feeling that the future of civil aviation was bound up at least as much in the development of research as in the production of financial support from the State.

Wing-Commander BEATTY, replying to the discussion, thanked the meeting for the very kind way in which his lecture had been received. The Chairman had mentioned that research was being carried out in connection with such problems as propeller silencing, and so on, but he would point out that hit-and-miss experiments sometimes leapt ahead of organised research, and he would exhort designers to keep on trying new ideas and methods. With regard to Major Kennedy's remarks, he had not specially considered mail machines in the paper simply because existing machines were far more suitable for goods and mails than for passengers, and the bulk of the traffic at the present time was passengers. He agreed with Major Turner that the title of the lecture did not exactly correspond with what was in it. As to the small size of Great Britain, it would be noticed that he had combined "existing highly-developed communications" with the small size of the country when he referred to the fact that in the past there was little prospect for commercial aviation. He did not say there was no prospect at present. He was sorry to hear that designers had not taken more advantage of Sir Samuel Instone's offer in the past.

At the conclusion of the proceedings a hearty vote of thanks was accorded Wing-Commander Beatty for his paper.

Mr. H. P. FOLLAND (*communicated*): Wing-Commander Beatty's paper is extremely interesting from the point of view of the designer, as it is papers of this description which point out to the designer the essential requirements for aircraft in any particular sphere. In war-time we received criticism on our types from the Air Force in the field; commercially, we look forward to the criticisms of users of commercial aircraft in the same way.

Wing-Commander Beatty mentions the rapid development of military types under war conditions. We must also assume that advancement in design will be more rapid as commercial aircraft are more universally used in such directions as postal aeroplanes, goods-carrying aeroplanes and passenger-carrying aeroplanes.

Wing-Commander Beatty also mentions requirements for the military competition of 1922, and states that a number of these have not yet been incorporated. This may probably be due to a general tendency in designing to obtain the best useful load. The carrying of special silencers, self-starters and intricate ventilation systems will only reduce this useful load when in competition with other designs or against other countries. An alternative to this would be a regulation insisting on self-starters, exhaust silencers and adequate ventilation; the latter is absolutely essential, and could be worked on similar lines to B.O.T. requirements for buildings at the present time. This could be agreed by the Committee.

With regard to the number of engines, I am of the opinion that the single-engine machine, as it stands, is a much safer proposition than the twin-engined machine, the latter meaning extra weight, duplication of the most troublesome systems, such as petrol, water and oil, and also two radiators. Very few of the twin-engined machines with more than half load can fly with one engine. I consider that the question of multi-engines in a cabin, driving two or more propellers, is a more satisfactory arrangement.

Commander Beatty raises the question with regard to the sizes of fuselages with larger cubic space per head in relation to high-powered engines; he also asks whether such a fuselage is practicable for single-engined machines.

I do not think that with engines up to 1,000 to 2,000 h.p. the size of the body should materially affect the propeller efficiency, providing that the cross-sectional area at the engine point is within reasonable limits.

It is rather interesting to note that a machine with a B.R.2 engine has a cross-sectional area of 11 square feet at the cowling. The Napier Lion engine, as fitted in the "Mars I.," which is 450 h.p., has only 6 square feet cross-sectional area to the cowling. The Napier "Cub," which is 1,000 h.p. engine, can be cowled in at the nose at little less than 14 square feet cross-sectional area, this being only 27 per cent. larger area than that of a Scout machine with B.R.2 engine. Therefore, providing the nose of the machine is faired within reason to the body, the propeller efficiency would not, I think, be likely to be affected. In the case of a blunt-nosed machine the question would have to be taken of propeller area to body area, and it would probably mean an extra large size propeller.

BOATS THAT FLY.

Juvenile Lecture, delivered before the Society, January 12th, 1922, by MAJOR D. C. M. HUME.

"The time has come," the Walrus said,
"To talk of many things;
Of shoes and ships and sealing wax,
Of cabbages and kings."

LEWIS CARROLL.

You all know those jolly words from "Alice's Adventures through the Looking Glass," and in a measure we are about to push our way through the melting mirror of hearsay to the strange world of wonderful facts, where boats fly, and men think nothing of the sort of ascent that blew the breath out of the poor White King when he received his first dusting in the air. We will talk, you and I, of shoes for aircraft—ships that fly and sealing wax that guards the secrets that have made the British seaplane the greatest example of its kind in all the wide world.

First of all you would like to find out, I know, how aircraft manage to fly at all.

You can find that out easily. Take a large box lid or other flat surface, hold it up vertically before you and run across the room with it. You can feel the air pressure on it opposing your motion. You can *feel* the air. You can realise that air has some substance about it—some density, some reluctance to get out of the way, some stickiness or viscosity as those solemn people called scientists call it.

Now come back again and do the run all over again, only this time hold the lid sloping with its top edge away from you and its lower edge in your waistcoat. This time you will feel a distinct tendency for the lid to lift upwards and fly out of your hands—in fact if you could run fast enough it would do so, or else take you up with it.

That is really how an aeroplane flies. A flat surface is rigged up at an angle to the horizontal and is rushed through the air at such a speed that the air does not get out of the way fast enough, and so the surface climbs over it, *i.e.*, is lifted up vertically. The engine of the aircraft is there to push the planes, etc., through the air at the required speed, the air, not the engine, lifts the aircraft, and the engine serves to keep it lifted by maintaining the forward speed.

It was found out many years ago that we can do considerably better than use a flat plate like the above. If the plate be curved in a special manner—cambered, as it is called—the lift which a given area can produce at a given speed is vastly increased. It was in the actual and scientific investigation of the fact that the famous Wright Brothers did work the pioneer value of which cannot be too strongly admired and remembered.

Now comes a curious fact. If we use such a curved or cambered plane the top side and its camber are of far more importance than the under side, for although there is direct positive pressure from the air on the underside there is now, owing to the shape of the top side, a decided suction or negative pressure on the top side. The curvature has caused the air to rise sharply at the nose of the wing, and it does not fall back to its normal position until just after the wings width, or chord as it is called, has passed—this means the air has produced a suction on the top side, and this helps the positive pressure on the under side, and the lift or upward force on an area of any particular size is thus increased.

Cambered wings at their best angle can be made to give eight or nine times the effect of a plain flat plate wing.

If the plane be sloped up at too great an angle to the direction of flight the effect on the air is no longer regular, the resistance to forward motions is greatly increased, and the air all tumbles about anyhow over the top side of the wing in whirls and eddies, and our useful suction or negative pressure is destroyed—the plane no longer lifts enough, and—if we are in an aircraft—down she comes; the aircraft is said to have "stalled." However, if she is high enough she can recover as she falls, diving nose downwards, and glide out again in a steady path at an angle to the direction of motion sufficiently small to maintain the necessary lift.

In order to avoid this sort of thing we must be able to control the angle at which our plane or wing is pushed through the air.

For this purpose we have to fit a tail. There is a vertical line along which we can imagine the whole lift of our plane to act—the line of centre of pressure the scientists call it. Our plane and all its supports have some weight, therefore it has a centre of gravity, or a place where all its weight may be imagined to be concentrated. If this centre of gravity is behind the line of lift the plane is on its way to a stall, if the centre of gravity is forward of the line of lift the plane is on its way to a nose dive. To stop it doing either we push out another small plane behind the main plane—a tail to balance it—and this being a fair distance away from our main plane can be a small affair. If we can make this tail lift it will push the main plane angle flatter, if we can make the tail plane loose lift it will drop down and increase the main plane angle. Thus, we have got a fore and aft control, we can dive or stall, "switchback" or fly level.

Incidentally for any given push by our engine the actual speed through the air depends upon our resistance to motion, and, as other parts of the aircraft remain practically the same, this means that our airspeed is according to the sharpness of the angle of our wings. So we have also obtained a *speed* control with our tail.

Now how are we going to turn—because we must turn if we want to come back?

We do this just like any other ship with a vertical rudder, put out at the same place as the tail in order to keep it conveniently small. But here is a little point about rudders that you must remember. They won't turn anything unless there is some fixed vertical surface in front of them—keel fin as it is called. An aircraft with no vertical surface at all except its rudder will not turn a corner, it will only slew round and carry on crabwise in its original direction of flight. So we have to fit keel fin forward of it to give the rudder something to push against, as it were, and so swing the nose round persistently as required to make a turn; this keel fin is usually provided by the body of the aircraft and other natural surfaces of its component parts. That is our directional control.

But if we turn a large weight—a large vehicle say—flatly like this we find a strong tendency for everything to slide outwards of the turn—to skid—you've all noticed this effect going round a comparatively flat corner in a bus or a car—the learned name for it is centrifugal force—well our aircraft will be subject to this and will skid outwards unless we make provision against it. On railways they bank up the track so that the centrifugal force is opposed by direct push on the rails—on motor and cycle racing tracks they bank up the track similarly to oppose this force and keep the vehicles from slipping outwards as they turn. In the air we cannot bank the air up, but we can bank the aircraft up so that any tendency to slip is opposed by the direct push of the wings bluff to the air.

Now, how are we going to do that?

We need to raise one wing more than the other, *i.e.*, one wing must develop more lift than the other. It can do this in two ways—one, if one wing goes faster

through the air than the other; two, if one wing's camber can be altered to increase the lift.

The first of these methods may be called the natural bank, for you will see at once that as the aircraft is turned by its rudder the outer wing's tip is going a lot faster than the inner wing's tip—just as the end men of a rank of soldiers have to speed along pretty lively to keep a line when wheeling, whilst the inside men have to go dead slow—consequently the outer wing develops more lift than the inside one and the aircraft banks.

This may or may not be enough to counteract the centrifugal force—if it is either too much or not enough we must use the second or artificial bank to correct the aircraft as required. To do this we fit the wing with a flap or movable back part, which when pulled down a little (and it only needs a very little) has the effect of sharpening the curvature of the top side of the wing, and thereby increases its lift. As this control is one designed to roll the aircraft it is not fitted all the way along the wing, but only where it will be most useful and most easy to work—as far away from the centre of gravity as possible, *i.e.*, at the wing tips.

So that, if our natural bank is too much or too little, we can modify it now by forcibly deflecting our end flaps or ailerons, as they are called, and correcting our altitude so that no side slipping takes place.

For simplicity we have only talked about one-plane machines—monoplanes—but for mechanical conveniences most aircraft and almost all seaplanes are biplanes. I have not got time to-day to explain to you the advantages of each as I am supposed to be telling you about seaplanes, but the facts we have considered are necessary so that you shall be able to understand just how and why a seaplane flies.

The seaplane is the most natural form of aircraft. Some of the earliest experiments were carried out over the water, because it's a nice safe sort of thing to fall into in case of failure, and because calm water is most uncommonly flat and there is nothing to catch in or fall over.

But a seaplane has to have some features which land aircraft don't have to bother about. Firstly, it must float easily, fully and lively like a cork, it must have every facility for coming away from the water when it wants to fly; it must be able to battle successfully with such rough water as it may be expected to encounter sometimes, *i.e.*, it must be seaworthy, and as the sea water and sea air are both very quick and powerful at rusting or otherwise eating away most metals the question of protection from such corrosion has to be ever before the seaplane designer, who has to do his work with one eye on the water and the other in the air, and the water eye must have a true marine outlook—the sailor vision—the naval understanding.

When a land machine is landed on the land it's down and done with; when a seaplane has settled on the water most of the fun is only just starting.

Seaplanes are of two kinds "shoes and ships"—float seaplanes and boat seaplanes. A float seaplane looks like an aeroplane put on two punt-like floats (though any designer will tell you how great a fallacy that conception really is). A boat seaplane looks like a rather bulgy motor launch with wings. Each type has its advantages and disadvantages, but one cannot lay down the law of superiority, as the particular use for which the aircraft is needed is the deciding factor. Floats for fighting—boats for bombing is not a bad gospel, but like most trite remarks, horribly incomplete. The float seaplane is often awkward and difficult to handle on the water by the pilot, but comparatively easy to handle by a motor boat or waders. The boat seaplane is almost the opposite. In the air the floats are a dead weight and a nuisance. In the air the boat seaplane hull is convenient, but the position of the engine up in the air is a nuisance in several ways. But it has to be away up there because when any seaplane is

rushing through the water getting up speed to get off it throws out almost solid water in a wave, and the rapidly revolving propeller doing perhaps one thousand revs. per minute has to be kept clear of this, or it will be smashed to smithereens.

The boat seaplane presents most of its problems in the hull.

The hull is built much like the hull of any small yacht, with a kind of basket work inside consisting of keel and fore and aft long pieces called stringers and athwartship members called timbers, frames and floors. On this framework is fastened the closely butted planking. In small boats one skin of this, perhaps as thin as 3/16in., or the thickness of a paper exercise book, in large hulls two or three skins giving a total thickness of perhaps ½in.

In order that the hull shall give the minimum resistance in the air when flying it is necessary for it to be smooth and even in shape—well streamlined as we call it. The best shape for this is a sort of cigar with a rounded nose and pointed tail.

If we were to build our hull in this form it would be lovely in the air, but unfortunately we should never be able to get it there. As we drove it through the water trying to get off we should find the water would cling to its curved sides, suck it down hard and even indeed probably run up its smooth sides and swamp it.

To get over this we have to fit on a special bottom—which is very different from anything we've been accustomed to in ordinary boats. This extra bottom is often outside or stuck on to the hull proper and consists of a flat surface which is usually V'd from the keel and extends from the nose to somewhere about the centre of gravity of the seaplane, at which position it is abruptly stopped off and forms a thwartship step.

The flat surface of the bottom will, you can imagine, help to lift the hull on to the surface of the water, just as the flat surfaces of the wing lift the aircraft up in the air—in fact the planing surface, as it is called—makes the hull "fly" in the water.

When the hull reaches the limit lift that this planing surface can impart to it it is riding on the step only—going along very fast—nearly fast enough for the wings to take up the weight and flights to be achieved. The step has also broken the flow of the water round the hull and stopped the clinging and sucking action referred to above. The water resistance has been falling rapidly as the hull began to lift out on to the step; a few more seconds for speeding up and the boat sails up into the air.

You will note in most boats and some floats, too, that there is a second step aft of the main step. Correctly designed this should do nothing in the way of lifting the hull out of the water, it is put there to stop any tendency to pitch fore and aft, or "porpoise"; if the hull rolls forward the planing bottom pushes it back—if it rides back tail down the rear step comes into play and, though small, it is a very efficient water planing surface and kicks the hull up on to an even keel again. The art of knowing how to place this step with regard to any particular form of forward planing bottom and any particular size of boat is one of the sealing wax secrets that has been discovered by painstaking research for years past and indeed is still being explored.

We find these things out by making a model hull about 3ft. long in wood and towing it along at definite speeds in a great tank like a swimming bath—the William Fronde national tank—at the National Physical Laboratory, Teddington—and cunning folk trained to observe these things deduce us valuable laws and guidance for future use. It is a very, very interesting subject because you cannot calculate much—you've just got to know and then use your judgment.

Boat seaplanes have to be fitted with wing tip floats on the bottom planes to prevent them rolling over sideways when at rest on the water. As soon as they start moving and have attained a speed of about 15 knots, most boat hulls

are laterally stable and do not require the help of the wing tip floats. Perhaps one day we shall be able to dispense with these. At present they are an absolute necessity on the water, but waste weight and resistance in the air.

Let me now tell you why the seaplane is so very important a kind of flying machine. I have told you it is a natural type of aircraft, it is natural both nationally and physically. To begin with there is twice as much water on this cheery old earth as there is land, not counting the thousands of inland lakes of inestimable use to the seaplane in various parts of the world, notably Canada for instance, which is dotted all over with them.

Beneath the seaplane at sea there is always an "aerodrome" in all directions; it is never limited by hedges and clear runs and such like restrictions that beset the land machine. It doesn't matter how much space is wanted to get it off, the space is there.

This means that the size of the seaplane can be only limited by the nature of the materials, etc., from which it is built—a very great and valuable asset for the seaplane.

Thus, seaplanes are generally of larger dimensions than land machines. In the late war we had hundreds of two-engine leviathans (I believe that is the right journalistic word!) of round about seven tons in weight, a few of 10 tons weight, and just now we are experimenting with 15 tons, whilst the designers in this country have well visualised the possibility of boat seaplanes up to 50 tons, and I have seen well-developed designs of two such flying boats.

I say it in no boasting spirit and with full knowledge of all it implies, that Great Britain is ahead of all the rest of the world in seaplane design and construction.

We are an island race, we have to get about over the water and so the seaplane comes naturally to us; we have developed it instinctively as being the type we *must* develop—just as our forefathers developed ships and made the Empire so must we develop seaplanes and keep it. We cannot do without our ships—don't imagine that—but we *can* make some of them fly and so increase their utility. Outlying spots in this vast Empire can be both efficiently patrolled and mothered and helped by a few large boat seaplanes working from a ship or shore base at one quarter the cost or less than the equivalent patrol vessels and crews, etc., and I look forward to the days when the large flying boats will be features of every port.

The boat seaplane, by its ability to be built big, is capable of long distances, say 2,000 miles, with small crews and mails, short distances, say 500 miles, with a number of passengers in complete comfort.

The seaplane is so much faster than anything that moves upon the surface of the waters that its time-saving qualities are self-evident, whilst it is not necessary to strain after record speeds, except so far as such design develops clean lines and consequent low resistance—or high air efficiency and correspondingly better carrying capacity in pounds or people.

One of the bugbears of land flying is the fear of being up after nightfall and having to land in the dark.

Thanks to an ingenious device no such fears need assail the seaplane provided it be clear of shipping. This device is called the Cooper night-landing stick, and it consists of a swinging pole or spar which can be hung down by the pilot over the side of the boat as he glides down towards the water. The top or boat end of this pole is connected on to the tail control of the seaplane.

The pilot glides down to the sea at a reasonably gentle angle—and having all the ocean to land in there is no necessity to make this angle steep—and the "stick" does the rest, for when the seaplane is about 20ft. above the water the lower end of the stick or pole touches the surface of the water and is naturally

swept backwards sharply. The swinging stick then operates the tail control flaps, or elevators as they are called, and the glide is flattened out—the descent checked —and the seaplane, perhaps with one or two more correcting kicks from the stick, settles safely and flatly down on to the water.

What of the men?

The men are bred in England. Clear-headed designers, skilled in all the many sciences that go to create a flying boat, primed with hard experience, versed in the arts and ingenuity that make success. The pilots, clear-eyed, quick-thinking wonder men, half sailors, half flying men, or, to parody Mr. Kipling, "a kind of giddy harumphrodite airman and sailor, too." Brave because it never occurs to them to be otherwise, cool because they are British, excellent because they are the salt of the earth.

A land pilot, I consider, is usually born and sometimes made—a seaplane pilot, like the poet, is born not made; and above them all stands the test pilot with the hands of an angel and the nerves of steel. It has been my honour to know many of them and it is my delight to accord them my admiration in this lecture. It takes a real man to take the first untried experimental aeroplane or seaplane up on its initial flight, knowing little or nothing of what tricks it may have, knowing only how it ought to behave, to put it fearlessly through its paces and return and give the waiting designer the valuable facts of its technical behaviour on which alone it may be improved and future designs conceived.

When we are young we say "Let's pretend"; when we are growing up we say, "I wish I could do so and so"; when we are grown up we say, "I predict"; and let me now have my little castle in the air and try to visualise the seaplane of some years hence—years when you are all members of this Society, and old, old members at that.

The Anglo-Argentine Air Line, running from Southampton to Buenos Aires, via Bordeaux, Lisbon, Canary Islands and Pernambuco and Rio. Tenders, small amphibian or wheeled boats, leave London (the Thames) every ten minutes for Southampton—half an hour's run. The air liner lies in a special dock, her wings, some 100 yards in span (and you who have tried to run it in 11-1/5 secs. know how long that is), tower 40ft. into the air; along the bottom one is a promenade deck fitted with rails, mooring bollards, etc. The passengers arrive from the tenders with personal baggage for two days, the weight of which has been checked in London, and walking along the deck find their way into the capacious hull, where they repair to their compact and ingeniously devised cabins—small but sufficient—on two decks with the dining-room and saloon forward. Above the hull is the sun room, a glass-sided chamber—divided for the smokers, etc.—and commanding an all-round view of the world from the air. Above this and in the top plane is the chart house and pilot captain's quarters. The crew live in the wing tip floats (the size of small yachts) and the steward and cook aft in the hull. The engines are behind the chart house and the vast metal propellers are arranged two out on the wings and maybe a third one forward of the sun room.

At last all is ready to proceed. The passengers are all up in the sun room, the mails are stowed in their parachute bags in the dropping traps in the bottom plane, electric fuel pumps are whirring quietly and the deck house doors are closed. The mate is shouting orders through his megaphone from the bridge on the top plane; the great centre propeller begins to flop round and then purrs away comfortably as the lock gates in front open and the Air Boat "Megalomania" glides out on the top of the tide into Southampton Water and proceeds on the surface at 20 knots clear of all shipping. She turns into the wind, the wing propellers commence to revolve faster and faster. The whole ship seems to sit back to her work. There is at first an ever-increasing smother of spray, which

gradually dies away as the speed increases. At 70 knots we are off Beaulieu and suddenly the water leaves us and the still sense of speed and restful flight comes over the ship as she rises steadily to the purring of her great propellers and shapes her course down Channel on her two days' run to Rio and the hardened travellers settle down to games and books under the watchful eye of the sun room steward.

Am I so very far ahead? I wonder! Maybe it is in the hands of some of you, my friends, to make my dream come true.

CORRESPONDENCE.

To the Editor of the AERONAUTICAL JOURNAL.

DEAR SIR,—There are two points of interest in connection with the Langley machine which appear to have been overlooked in Mr. Griffith Brewer's paper and also in the discussion which followed.

The first point is, that Langley was attempting to fly in 1903 with a machine having a loading of about 13 ounces to the square foot. I do not know whether this is an impossible task or whether it has ever been performed, but it would be interesting to know whether, in addition to attempting to fly, Langley was not trying to make a performance which has never even yet, with all the flying experience of to-day, been accomplished, namely to fly with a loading of less than 1lb. to the sq. ft.

The other point will only be within the knowledge of visitors to the U.S. Museum at Washington. There, in the hall, two models are suspended, one model that of Hargrave, which is labelled "Hargrave Flying Machine. Driven by compressed air engine. Flew 312ft. at Clifton, N.S. Wales, in 1891." This model hangs in a modest little corner shaded by the gallery of the Museum. Out in the open, lighted by the windows above the gallery, is suspended the larger Langley model, labelled as follows:—"Langley Flying Machine. The first successful flight made by a machine heavier than air driven by its own power was made by this steam flying machine on May 6, 1896, at Quantico, Virginia, over the Potomac River, with a steam pressure of 150 pounds."

What I should be interested to know, would be what the word "successful" means on the Langley model. If you omit the word "successful," the label is obviously incorrect, because the Langley model did not make the first flight by a machine heavier than air driven by its own power, because of Hargrave's model which did this five years earlier. There is some subtle difference, therefore, in the word "successful," which distinguishes the Langley model from the Hargrave model, and for the benefit of the general visitors to the Museum it would be well to have some explanation of the Smithsonian definition of the word "successful." Is it the same as the word "substantially," or "practically"? As the well-known judge once said, when he was told that a door was "practically" shut, he knew very well it was open. No doubt the word "successful" refers to the duration of the flight and the size of the machine. It would apparently relate to the duration only, because when the Hammondsport machine was tried at Hammondsport later and flew less than 312ft., it was "successful" according to the official report. What may therefore be successful in a large machine is apparently not successful in a small one. No doubt some of the Smithsonian scientists can help to elucidate the meaning of this elusive word.—Yours truly,

JAMES GUTHRIE.

750, Prospect Avenue, Cleveland, O.
January 5, 1922.

Berlin Lichterfelde,
Marthastr 5.

To the Editor of the AËRONAUTICAL JOURNAL.

Dear Sir,—Many thanks for sending the AËRONAUTICAL JOURNAL, the contents of which has found my greatest interest.

As I have always been the fellow worker of my deceased brother in his aeronautical researches, I am well informed about the proceedings in the investiga-

tions of flying. Please permit me to take part in answering the question: "Who is the inventor of the flying machine?"

As Mr. Handley Page quite right mentioned, every invention is based upon the preparatory work of several students. This preparatory work may it be purely scientifical or refer to mechanical appliances to introduce science into practical use, can be traced to every invention. It has always been the habit to spend the laurel to the victor in the race to success and I have never declined to call the Brothers Wright as the true inventors of the flying machine.

If Mr. Langley would live now and claimed to be the real inventor I am sure the world would laugh at him, but as far as I am informed he never rose this claim.

His apparatus did not fly because it was not properly constructed, and the novelty in the construction, the vaulted section of the wings, was no invention of Mr. Langley's, but of the Brothers Lilienthal. Mr. Langley got his information about the increased lifting force and favourable direction of the resulting air pressure by the book, "Der Vogelflug, als Grundlage der fliegekunst," published 1886 by Otto Lilienthal under my assistance, and by our personal information when he called at us 1895. We showed to him our stock of gliders and my brother made several glides at our experimenting place at Lichterfelde. Myself gave the explanations in English language.

Although the Brothers Wright got also one of our gliders which had been ordered by Mr. Chanute and they made their first experiments with our apparatus, I do not deny to them the glory of inventorship. They have made the first man flying from the ground and with this fact the dispute must stop.

If the claim of the Smithsonian Institution should succeed my brother and myself could just as well be entitled to raise the same claim. Our gliders, when driven forward by a screw propeller, would have been able to fly, but at that time, before 1896, we were not able to secure a motor light and powerful enough for this purpose. We had been dealing with Mr. Benz, of Stuttgart, who built the first explosion motors, but he declined to construct a motor that could suit our demands.

Our investigations and measurements of the air resistance on vaulted planes goes as far back as 1872. They are published in the above-mentioned book. A second edition is published in England, "Bird Flight," by myself.

You will see that flying has been made possible not only by the vaulted wings and not only by the light and powerful motor, but by both factors, and the man who brought both means to an harmonic combination is entitled to be called the inventor of the flying machine.

There is no doubt that the Wrights have been these men.

I am, Dear Sir, yours truly,

GUSTAV LILIENTHAL.

You would oblige me to send enclosed letter to Mr. Griffith Brewer, whose address I don't know.—G.L.

OBITUARY.

EDWARD P. FROST, J.P., D.L.

One more link with the past has gone in the death on 26th January of Mr. Edward Purkis Frost, one of the oldest pioneers of aviation. Born in 1842, he early became interested in the subject of flight and his name first appears in the list of members of the Aeronautical Society in 1875. In 1880 he was elected to the Council and became President of the Society in 1908. Among the old "Reports" of the Society his name frequently appears, and in 1883 he read a paper on "Aeronautics, with remarks on a visit to the Aeronautical Exhibition in Paris." In the 23rd Report is another paper by him referring to his experiments on feathers.

As a typical country squire, rather than the scientific engineer, Mr. Frost was ever watching the flight of birds and critically examining their wings. Insects and even winged seeds were also objects of his close study. Living in one of the finest partridge districts in England, Six-Mile Bottom, in Cambridgeshire, he was a keen shot and had every opportunity for studying the flight of these and other birds. The structure of the feather was his special problem. From small models of artificial feathers he evolved larger ones till he made some of 14 feet long, one of which was exhibited at a meeting of the Society in 1891. The main rib being on one side of the central axis, when the feather was beaten downwards, with ever so great an effort it always slipped away to the side, showing the propulsive force of a natural wing beat.

This led him to the construction of a full-sized flying machine of the "ornithopter" or beating-wing type, which took him ten years to build. It was originally supposed to be an exact imitation of a crow, though as eventually carried out it became very different, having supplementary aeroplanes and other features. It had a span of 30 feet to wing tip and was composed of 80 large artificial feathers. It was to be actuated by a steam engine, the whole weight, including engine and boiler, being 650lbs. But great difficulties were experienced with the engine, which did not develop so great a power as was anticipated, and the machine remained for many years merely as a monument of patient endeavour.

In 1902 Mr. Frost started on another series of experiments, in conjunction with Dr. Hutchinson and Mr. D'Esterre. These were described and illustrated in the AERONAUTICAL JOURNAL for July, 1903. The larger model consisted of a pair of wings, 20 feet across, actuated by a 3 h.p. petrol engine. These were mounted on a light steel framework on wheels, and were arranged to flap 100 times a minute.

King Edward, when Prince of Wales, showed much interest in Mr. Frost's experiments, and during his shooting expeditions to the neighbourhood visited the sheds and workshops.

Mr. Frost, among many other interests, made a study of the subject of universal peace, and wrote an interesting book, entitled, "Safeguards for Peace: A Scheme of State Insurance Against War," published in 1905.

To his friends he will ever be remembered as a courteous gentleman of the old school, enthusiastic on his hobbies, and ever ready to assist the cause of aeronautics in an unselfish and retiring manner.

PUBLICATIONS.

The following papers, etc., are published by the Society:—

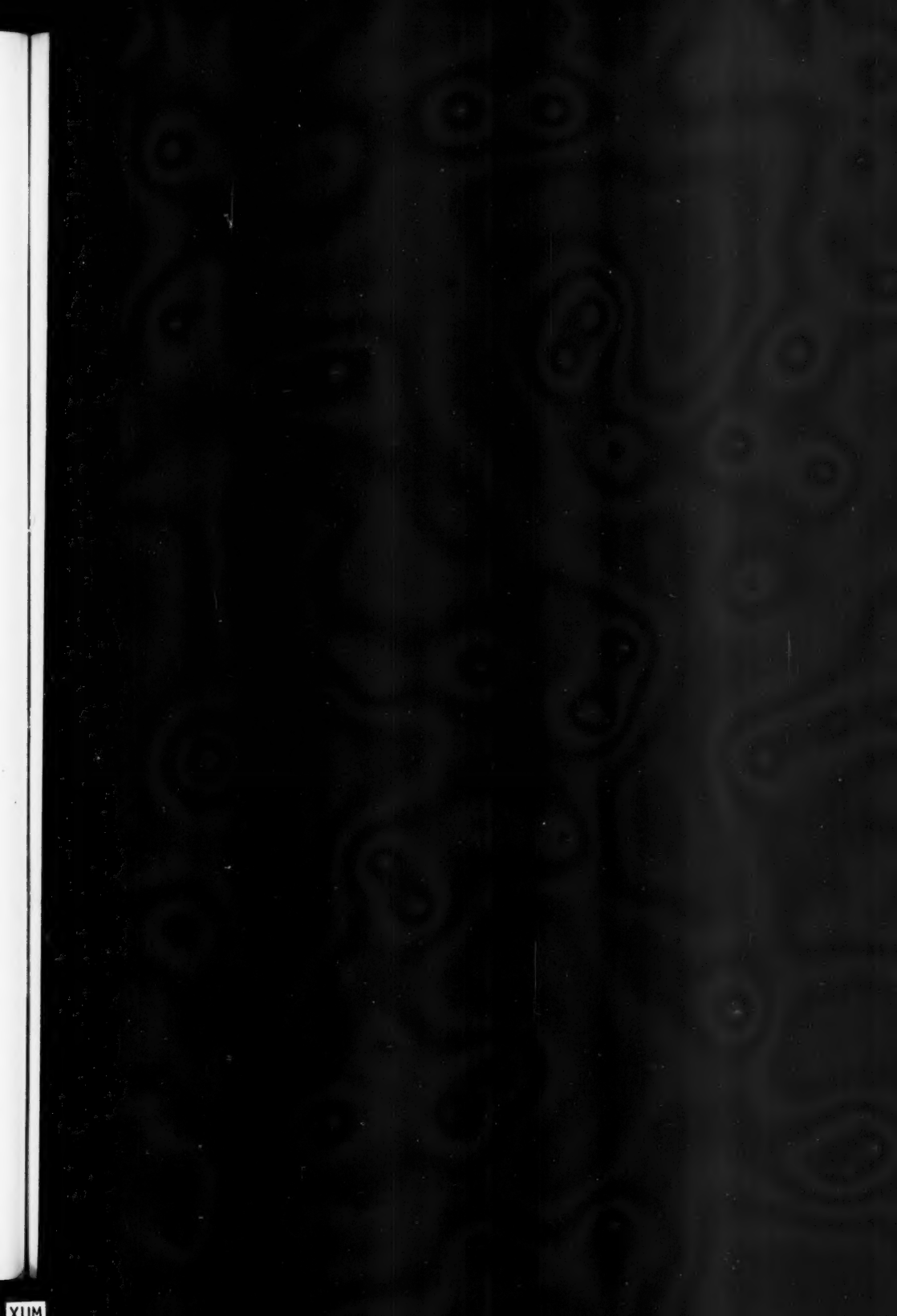
Transactions.

1. "The Calculation of Stresses in Aeroplane Wing Spars," by Arthur Berry, M.A. ... ... 5s. 0d.
2. "Position Fixing in Aircraft during Long Distance Flights over the Sea," by Instructor-Commander T. Y. Baker, R.N., and Major L. N. G. Filon, D.Sc., F.R.S., late R.A.F. ... 5s. 0d.
3. "Aero Engine Efficiencies," by Dr. A. H. Gibson ... ... 5s. 0d.

Aeronautical Classics.

Reprints of the Work of Early Pioneers on whose theories modern flight is based.

1. "Aerial Navigation," by Sir George Cayley (1809) ... ... 21s. 0d.
2. "Aerial Locomotion," by F. H. Wenham (1866) ... ... 1s. 0d.
3. "The Art of Flying," by Thomas Walker (1810) ... ... 1s. 0d.
4. "The Aerial Ship," by Francesco Lana (1670) ... ... 1s. 0d.
5. "Gliding," by Percy S. Pilcher (1897) ... ... 1s. 0d.
6. "The Flight of Birds," by G. A. Borelli (1680) ... ... 1s. 0d.

Miscellaneous Publications.

"Steels Used in Aero Work," by Dr. W. H. Hatfield ... ... 5s. 0d.
"Methods of Measuring Aircraft Performances," by Captain H. T. Tizard ... ... 1s. 6d.
"The Screw Propeller in Air," by M. A. S. Riach ... ... 2s. 6d.
"The High Tension Magneto," by A. P. Young ... ... 5s. 0d.
"Commercial Aeronautics," by G. Holt Thomas ... ... 2s. 6d.
"The Training of Aeronautical Engineers," by R. M. Walmsley and C. E. Larard ... ... 2s. 6d.
"Steel Tubes for Aircraft," by W. W. and A. G. Hackett ... 2s. 6d.
"Timber," by W. H. Barling ... ... 5s. 0d.
"Design of Aeroplane Struts," by W. H. Barling and H. A. Webb 2s. 6d.
"Stress Optical Experiments," by Major A. R. Low ... ... 5s. 0d.
"Medical Aspects of Aviation," by Dr. L. E. Stamm ... ... 2s. 6d.
"Struts of Conical Taper," by H. A. Webb and Miss E. D. Lang 1s. 6d.
"Shop Practice in Respect to Aircraft Steel," by H. P. Philpot ... 5s. 0d.
"The Rigging of Aeroplanes," by R. J. Goodman Crouch ... 5s. 0d.
"Progress of Aviation during the War Period," by Dr. L. Bairstow 10s. 0d.
"Flight of Seagulls," by Dr. E. H. Hankin ... ... 2s. 0d.
"Chronology of Aviation," by H. Maxim and W. J. Hammer ... 1s. 0d.
"Report of the Bird Construction Committee" ... ... 10s. 6d.
"Glossary of Aeronautical Terms" ... ... 2s. 6d.
"London-Paris Service. Safety and Economy Committee's Report" ... ... 1s. 6d.